Report Date: 30 Jun 2014

Summary Report for Individual Task
551-88L-2068
Perform Metal Welding and Cutting
Status: Approved

Distribution Restriction: Approved for public release; distribution is unlimited.

Destruction Notice: None

Foreign Disclosure: FD5 - This product/publication has been reviewed by the product developers in coordination with the [installation/activity name] foreign disclosure authority. This product is releasable to students from all requesting foreign countries without restrictions.

Condition: Given an operational welding machine aboard a vessel, at sea, at anchor or moored alongside a pier, day or night, under all sea and weather conditions, while wearing appropriate PPE, (i.e. hearing protection,welding gloves, eye protection, welding shield, apron, etc.), lock out tag out kit and a marine rail tool box.

Standard: The Soldier correctly performs metal welding and cutting aboard an Army vessel, IAW the appropriate Technical Manual and local SOPs, without injury to self or others and without damage to equipment.

Special Condition: None

Safety Risk: Extremely High

MOPP 4:

Task Statements

Cue: None

DANGER

None

WARNING

None

CAUTION

None

Remarks: None

Notes: None

Performance Steps

1. Identify welding metals, protective clothing and equipment for electric arc welding.

a. Welding is any metal joining process wherein coalescence is produced by heating the metal to suitable temperatures, with or without the application of pressure and with or without the use of filler metals.

b. Metals are divided into two classes, ferrous and nonferrous.

(1) Ferrous metals are those in the iron class and are magnetic in nature.

(a) Iron

(b) Steel

(c) Alloys related to them

(2) Nonferrous metals are those that contain either no ferrous metals or very small amounts.

(a) Aluminum

(b) Copper

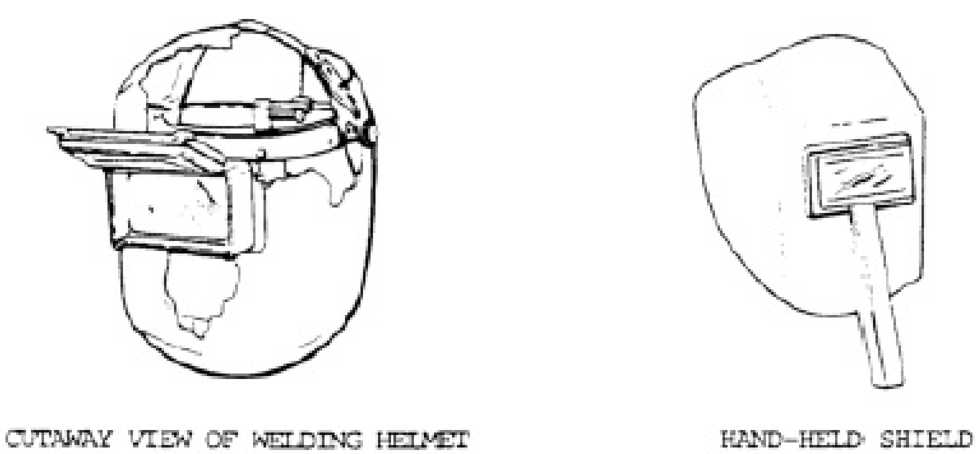
(c) Magnesium

(d) Lead

(e) Similar groups

c. Personal protective clothing and equipment.

(1) Helmets and shields.

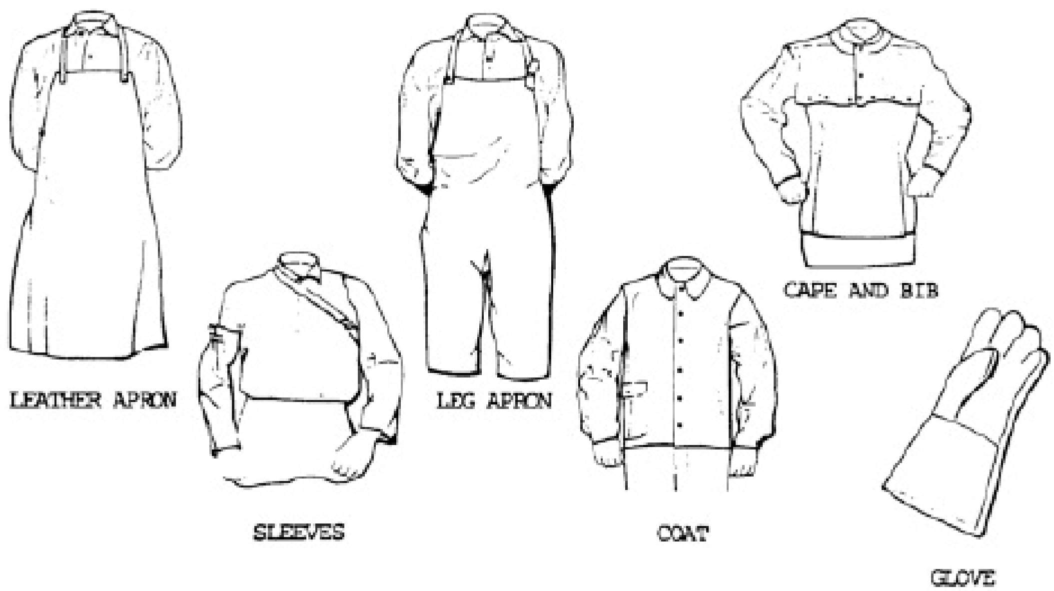


Helmets and Shields
Figure 551-88L-2068_01

(2) Safety goggles

Safety Goggles
Figure 551-88L-2068_02

(3) Protective clothing



Protective Clothing
Figure 551-88L-2068_03

(4) Protective equipment

(a) Where there is exposure to sharp or heavy falling objects or a hazard of bumping in confined spaces, hard hats or head protectors must be used.

(b) For welding and cutting overhead or in confined spaces, steel toed boots and ear protection must also be used.

(c) When welding in any area, the operation should be adequately screened to protect nearby workers or passers-by from the glare of welding.

d. Ventilation for general welding and cutting.

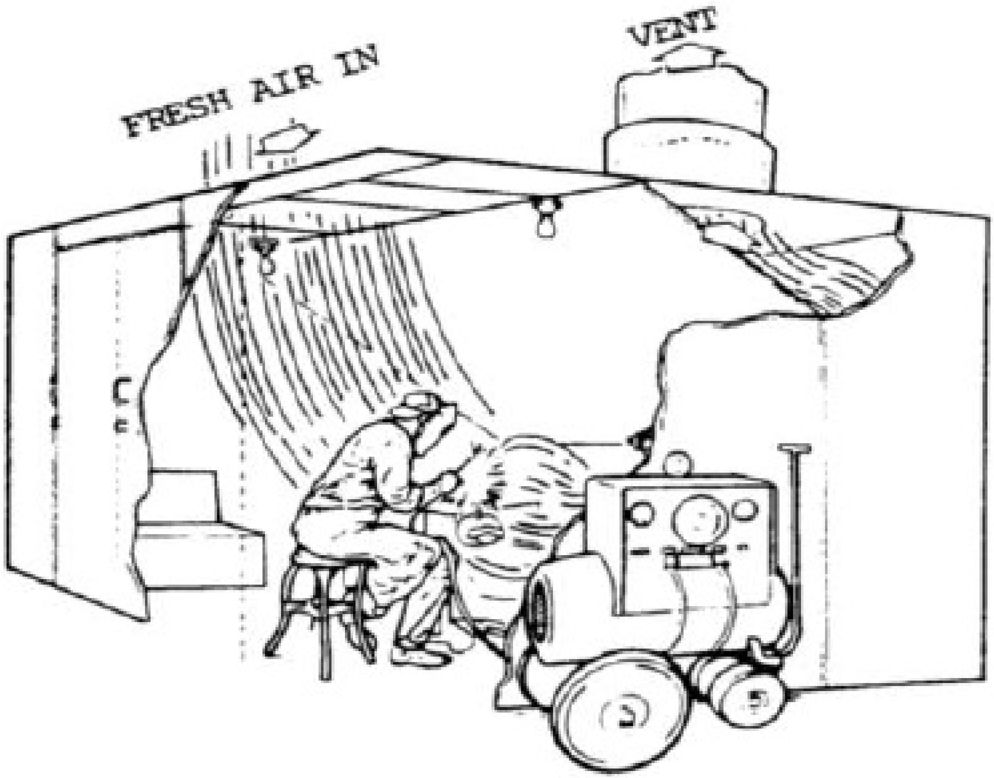
(1) Mechanical ventilation shall be provided when welding or cutting is done on metals under the following conditions.

(a) In a space less than 10,000 cu ft (284 cu m) per welder.

(b) In a room having a ceiling height of less than 16ft (5 m).

(c) In confined spaces or where the welding space contains partitions, balconies, or other structural barriers to the extent that they significantly obstruct cross ventilation.

(2) Minimum rate of 200cu ft per minute (57 cu m) per welder, except where local exhaust heeds or airline respirators approved by the US Bureau of Mines, National Institute of Occupational Safety and Health, or other government-approved testing agency, are used for ventilation.



Welding Booth with Mechanical Ventilation
Figure 551-88L-2068_04

(3) Local exhaust ventilation may be obtained by either of the following

(a) Hoods – Freely movable hoods or ducts are intended to be placed by the welder as near as practical to the work being welded.

(b) Fixed enclosure – With a top and two or more sides which surrounds the welding or cutting operations will have a rate of airflow sufficient to maintain a velocity away from the welder of not less than 100 linear ft per minute.

(4) Ventilation in confined spaces.

(a) Air replacement – All welding and cutting operations in confined spaces shall be adequately ventilated to prevent the accumulation of toxic materials or possible oxygen deficiency.

(b) Airline respirators – In circumstances where it is impossible to provide adequate ventilation in a confined area, airline respirators or hose masks, approved by the US Bureau of Mines, National Institute of Occupational Safety and Health, or other government approved testing agency, will be used for this purpose.

(c) Self-contained units – in areas immediately hazardous to life, hose masks with blowers or self-contained breathing equipment shall be used.

(d) Outside helper – Where welding operations are carried on in confined spaces and where welders and helpers are provided with hose mask, hose masks with blowers, or self-contained breathing equipment, a worker shall be stationed on the outside of such confined spaces to ensure the safety of those working within.

e. Welding in confined spaces.

(1) A confined space is intended to mean a relatively small or restricted space such as a tank, boiler, pressure vessel, or small compartment of a vessel or tank.

(2) When welding or cutting is being performed in any confined space, the gas cylinders and welding machines shall be left on the outside.

(a) Where a welder must enter a confined space through a manhole or other all opening, means will be provided for quickly removing him in case of emergency.

(b) When arc welding is suspended for any substantial period of time, such as during lunch or overnight, all electrodes will be removed from the holders with the holders carefully located so that accidental contact cannot occur.

(c) After welding operations are completed, the welder will mark the hot metal or provide some other means of warning other workers.

(d) The electric motors most commonly used to drive the welding generators are 220/440 volts, 3 phase, 60 cycle.

f. Electric arc welding equipment and accessories.

(1) Electric arc welding process, an arc is produced between an electrode and the work piece (base metal).

(a) The arc is formed by passing a current between the electrode and the workpiece across the gap.

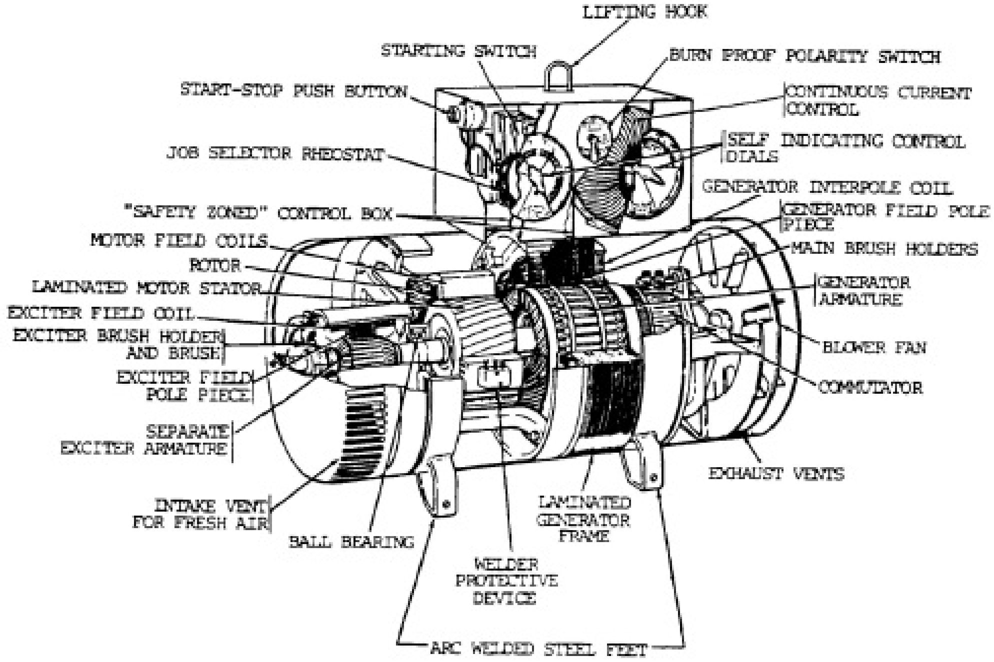
(b) The current melts the base metal and the electrode (if the electrode is a consumable type), creating a molten pool.

(2) Direct current welding machine has a heavy duty direct current generator.

(a) The machines rated 150 and 200 amperes, 30 volts, are used for light shielded metal-arc welding and for gas metal-arc welding; also used for general purpose job shop work.

(b) The machines rated 200, 300, and 400 amperes, 40 volts used for general welding purposes by machine or manual application.

(c) Machines rated 600 amperes, 40 volts, are used for submerged arc welding and for carbon-arc welding.

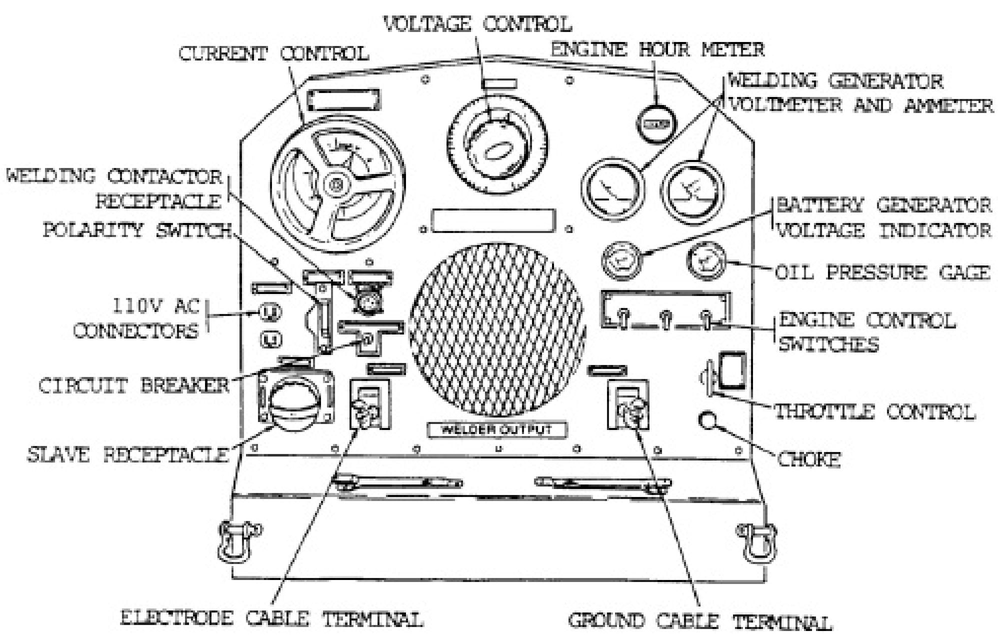


Cutaway View of DC Welding Generator
Figure 551-88L-2068_05

(d) The electric motors most commonly used to drive the welding generators are 220/440 volts, 3 phase, 60 cycle.

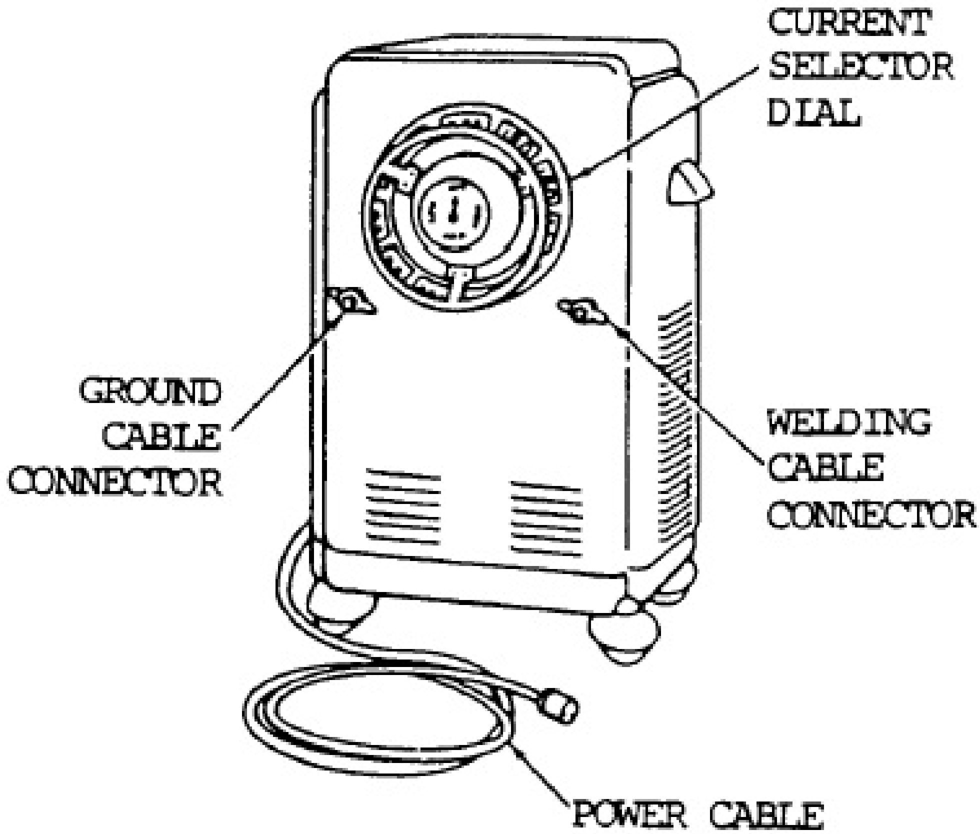
(e) In most direct current welding machines, the generator is of the variable voltage type, and is arranged so that the voltage is automatically adjusted to the demands of the arc.

(f) The welding current amperage is also manually adjustable, and is set by means of a selector switch or series of plug receptacles.



Direct Current Welding Machine
Figure 551-88L-2068_06

(3) Alternating current arc welding machines in use are of the single operator, static transformer type.



Alternating Current Arc Welding Machine
Figure 551-88L-2068_07

(a) The transformers are generally equipped with arc stabilizing capacitors.

(b) Current control is provided by means of an adjustable reactor in the output circuit of the transformer.

2. Explain electric arc theory and welding procedures.

a. In the arc welding process, the weld is produced by the extreme heat of an electric arc drawn between an electrode and the workpiece, or in some cases, between two electrodes.

b. Welds are made with or without the application of pressure and with or without filler metals.

c. Arc welding processes may be divided into two classes based on the type of electrode used.

(1) Metal electrodes: arc welding processes that fall into this category include bare metal-arc welding, stud welding, gas shielded stud welding, submerged arc welding, gas tungsten arc welding, gas metal-arc welding, shielded metal-arc welding, atomic hydrogen welding, arc spot welding, and arc seam welding.

(2) Carbon electrodes: arc welding processes that fall into this category include carbon-arc welding, twin carbon-arc welding, gas carbon-arc welding, and shielded carbon-arc welding.

d. The arc is used as a concentrated source of high temperature heat that can be moved and manipulated to melt the base metal and filler metal to produce welds.

e. Two types of welding arcs:

(1) The non-consumable electrode does not melt in the arc and filler metal is not carried across the arc stream.

(2) The consumable electrode melts in the arc and is carried across the arc in a stream to become the deposited filler metal.

f. The main function of the arc is to produce heat.

g. The curve of an arc takes on a nonlinear form which in one area has a negative slope.

(1) The arc voltage increases slightly as the current increases.

(2) The conductivity of the arc increases at a greater rate than simple proportionality to current.

h. The arc is maintained when electrons are emitted from the surface of the negative pole (cathode) and flow across a region of hot electrically charged gas to the positive pole (anode), where they are absorbed (cathode and anode are electrical terms for the negative and positive poles.)

i. The arc length or gap between the electrode and the work can be divided into three regions.

(1) Central region

(2) Region adjacent to the electrode

(3) Region adjacent to the work

j. In the carbon arc, a stable dc arc is obtained when the carbon electrode is negative.

(1) In this condition, about 1/3 of the heat occurs at the negative pole (cathode), or the electrode.

(2) At about 2/3 of the heat occurs at the positive pole (anode), or the workpiece.

k. The forces that cause metal to transfer across the arc are similar for all consumable electrode arc welding processes.

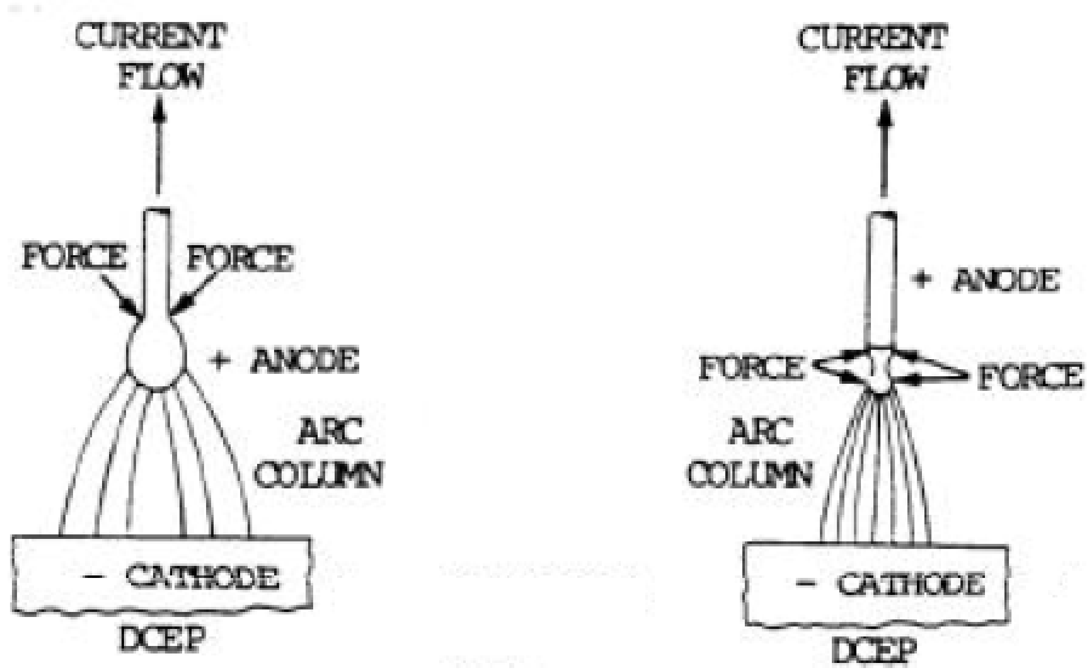
l. Several forces affect the transfer of liquid metal across an arc.

(1) Surface tension of a liquid causes the surface of the liquid to contract to the smallest possible area.

(2) The welding arc is constricted at the electrode and spreads or flares out at the workpiece.

(3) Earth gravity detaches the liquid drop when the electrode is pointed downward and is a restraining force when the electrode is pointing upward.

(4) Electromagnetic force also helps transfer metal across the arc.



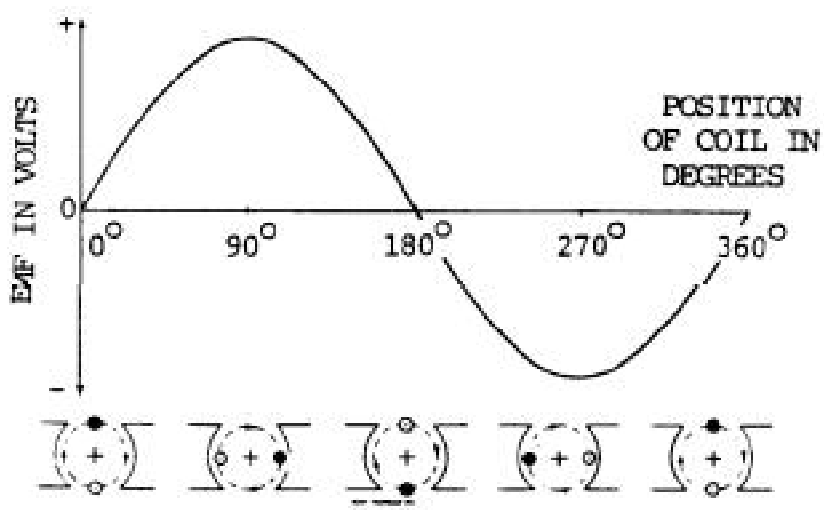
DC Consumable Electrode Metal Arc
Figure 551-88L-2068_08

m. AC welding: alternating current is an electrical current which flows back and forth at regular intervals in a circuit.

(1) When the current rises from zero to a maximum, returns to zero, increases to a maximum in the opposite direction, and finally returns to zero again, it is said to have completed one cycle.

(2) A cycle is divided into 360 degrees.

(3) The number of times this cycle is repeated in one second is called the frequency, measured in hertz.



Sine Wave Generation
Figure 551-88L-2068_09

(4) Alternating current for arc welding normally has the same frequency as the line current.

(5) Alternating current and voltage are measured with ac meters.

(6) An alternating current is measured in terms of the ampere.

(7) Electrical power for arc welding is obtained in two different ways.

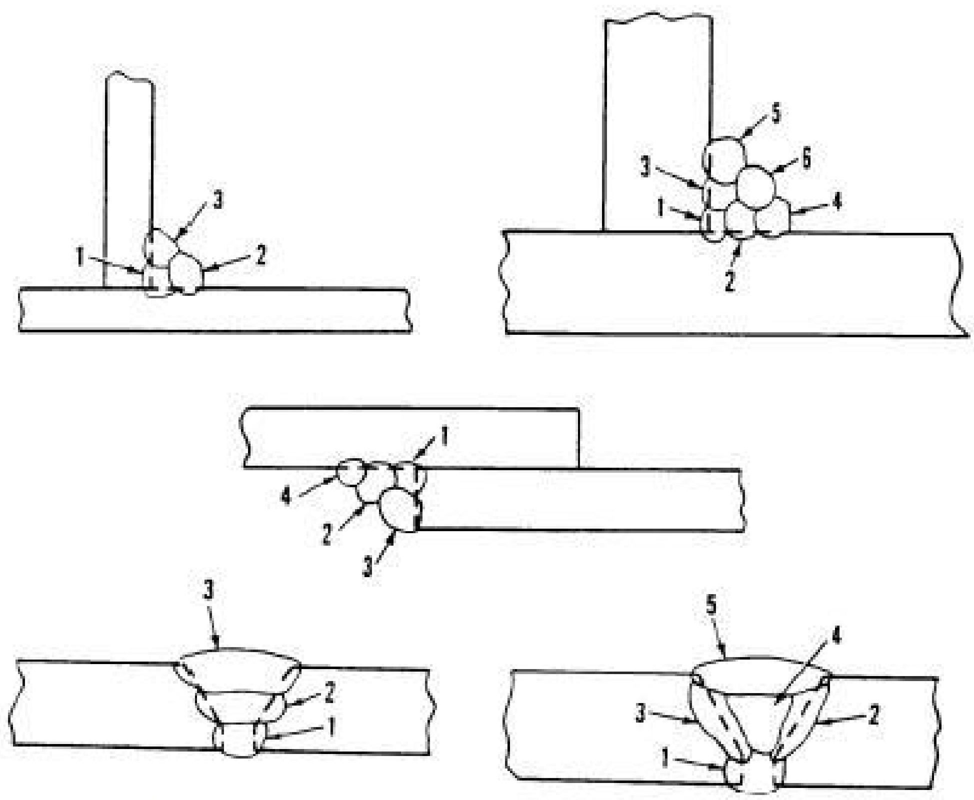
(8) It is either generated at the point of use

(9) Converted from available power from the utility line

(10) With an alternating flow of current, the arc is extinguished during each half-cycle as the current reduces to zero, requiring re-ignition as the voltage rises again.

(11) The greater the arc length, the less the arc gas will be heated by the hot electrode terminals, and a higher re-ignition potential will be required.

n. Multilayer welding is used when maximum ductility of a steel weld is desired or several layers are required in welding thick metal.



Multi-layer Welding
Figure 551-88L-2068_10

o. The multilayer method allows the welder to concentrate on getting good penetration at the root of the V in the first pass or layer.

(1) This method permits the metal deposited in a given layer to be partly or wholly refined by the succeeding layers, and therefore improved in ductility.

(2) The lower layer of weld metal, after cooling, is reheated by the upper layer and then cooled again.

(3) The weld area is being heat treated.

p. Shielded metal-arc welding is the most widely used method for general welding applications.

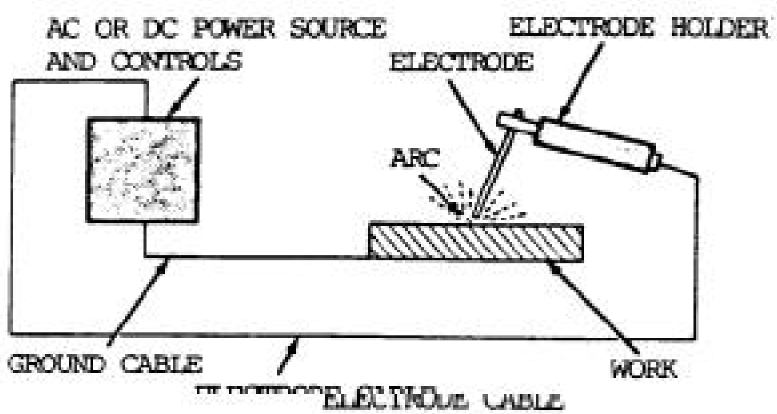
(1) It is also referred to as metallic arc, manual metal-arc, or stick-electrode welding.

(2) It is an arc welding process in which the joining of metals is produced by heat from an electric arc that is maintained between the tip of a covered electrode and the base metal surface of the joint being welded.

(3) The core of the covered electrode consists of either a solid metal rod of drawn or cast material, or one fabricated by encasing metal powders in a metallic sheath.

(4) Arc shielding is obtained from gases which form as a result of the decomposition of certain ingredients in the covering.

(5) Shielded metal arc welding employs the heat of the arc to melt the base metal and the covering of a consumable electrode.



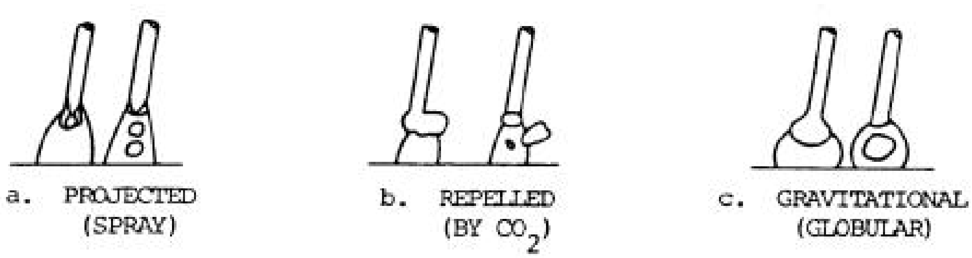
Elements of a Typical Welding Circuit for Shielded Metal Arc Welding
Figure 551-88L-2068_11

q. Welding begins when an electric arc is struck between the tip of the electrode and the work.

(1) Gravity is the principal force which accounts for the transfer of filler metal in flat position welding.

(2) In other positions, the surface tension is unable to retain much molten metal and slag in the crater.

(3) Therefore, smaller electrodes must be used to avoid excessive loss of weld metal and slag.



Three Types of Free-Flight Metal Transfer in a Welding Arc
Figure 551-88L-2068_12

(4) Gases are produced by the burning and volatilization of the electrode coating, and are expanded by the heat of the molten electrode tip.

(5) The coating extending beyond the metal tip of the electrode controls the direction of the rapid gas expansion and directs the molten metal globule into the weld metal pool formed in the base metal.

(6) The electromagnetic forces produced by the voltage across the arc pulls the small, globule of metal on to the workpiece, regardless of the position of welding.

(7) The force which keeps the filler metal and slag globules in contact with molten base or weld metal in the crater is known as surface tension.

(8) It helps to retain the molten metal in horizontal, vertical, and overhead welding, and to determine the shape of weld contours.

r. In addition to establishing the arc and supplying filler metal for the weld deposit, the electrode introduces other materials into or around the arc. Depending upon the type of electrode being used, the covering performs one or more of the following functions:

(1) Provides a gas to shield the arc and prevent excessive atmospheric contamination of the molten filler metal as it travels across the arc.

(2) Provides scavengers, deoxidizers, and fluxing agents to cleanse the weld and prevent excessive grain growth in the weld metal.

(3) Establishes the electrical characteristics of the electrode.

(4) Provides a slag blanket to protect the hot weld metal from the air and enhance the mechanical properties, bead shape, and surface cleanliness of the weld metal.

(5) Provides a means of adding alloying elements to change the mechanical properties of the weld metal.

3. Demonstrate basic knowledge of metal welding and cutting.

a. Gases have one common property: they all require oxygen to support combustion; gases must have the following:

(1) High flare temperature.

(2) High rate of flame propagation.

(3) Adequate heat content.

(4) Minimum chemical reaction of the flame with base and filler metals.

b. Base metal preparation.

(1) Dirt, oil, and oxides can cause incomplete fusion, slag, inclusions, and porosity in the weld.

(2) Contaminants must be removed along the joint and sides of the base metal.

(3) The root opening for a given thickness of metal should permit the gap to be bridged without difficulty, yet it should be large enough to permit full penetration.

(4) The thickness of the base metal at the joint determines the type of edge preparation for welding.

(5) Joint edges ¼ in. and thicker should be beveled.

(6) A square groove edge preparation is the easiest to obtain.

(a) This edge can be machined, chipped, ground, or oxygen cut.

(b) The thin oxide coating on oxygen-cut surface does not have to be removed, because it is not detrimental to the welding operation or to the quality of the joint.

(c) A bevel angle can be oxygen cut.

c. Multiple layer welding.

(1) Multiple layer welding is used when maximum ductility of a steel weld in the as-welded or stress-relieved condition is desired, or when several layers are required in welding thick metal.

(2) Multiple layer welding is done by depositing filler metal in successive passes along the joint until it is filled.

(3) This procedure enables the welder to obtain complete joint penetration without excessive penetration and overheating while the first few passes are being deposited.

(4) The welder can avoid oxides, slag inclusions, and incomplete fusion with the base metal.

(5) Grain refinement in the underlying passes as they are reheated increases ductility in the deposited steel.

(6) The final layer will not have this refinement unless an extra pass is added and removed or the torch is passed over the joint to bring the last deposit up to normalizing temperature.

d. Weld quality.

(1) The appearance of a weld does not necessarily indicate its quality.

(2) Visual examination of the underside of a weld will determine whether there is complete penetration or whether there are excessive globules of metal.

(3) Oversized and undersized welds can be observed readily.

(4) Although other discontinuities, such as incomplete fusion, porosity, and cracking may or may not be apparent; excessive grain growth or the presence of hard spots cannot be determined visually.

e. Working pressures for welding operations.

(1) The required working pressure increases as the tip orifice increases.

(2) The smaller number always indicates the smaller diameter.

Note:
Oxygen pressures are approximately the same as acetylene pressures in the balanced pressure type torch. Pressures for specific types of mixing heads and tips are specified by the manufacturer.

Table 5-2. Balanced Pressure Type Torch

Tip Size No.	Oxygen psi	Acetylene psi
NOTE Tips are provided by a number of manufacturers, and sizes may vary slightly.		
1	2	2
2	2	2
3	3	3
3	3	3
5	3.5	3.5
6	3.5	3.5
7	5	5
8	7	7
9	9	9
10	12	12

Balanced Pressure Type Torch
Figure 551-88L-2068_13

Table 5-1. Low Pressure or Injector Type Torch

Tip Size No.	Oxygen psi	Acetylene psi
NOTE Tips are provided by a number of manufacturers, and sizes may vary slightly.		
0	9	1
1	9	1
2	10	1
3	10	1
4	11	1
5	12	1
6	14	1
7	16	1
8	19	1
10	21	1
12	25	1
15	30	1

Low Pressure or Injector Type Torch
Figure 551-88L-2068_14

f. Flame adjustment and flame types.

(1) The oxyfuel gas welding torch mixes the combustible and combustion supporting gases.

(2) It provides the means for applying the flame at the desired location.

(3) The inner cone or vivid blue flare of the burning mixture of gases issuing from the tip is called the working flare.

(4) The closer the end of the inner cone is to the surface of the metal being heated or welded, the more effective is the heat transfer from flame to metal.

(5) The chemical action of the flame on a molten pool of metal can be altered by changing the ratio of the volume of oxygen to acetylene issuing from the tip.

(6) Most oxyacetylene welding is done with a neutral flame having approximately a 1:1 gas ratio.

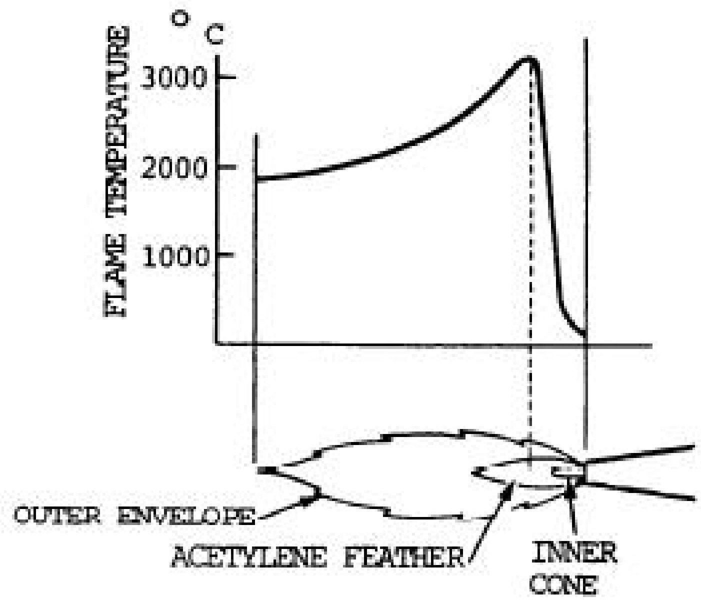
g. Flare adjustment.

(1) Torches should be lighted with a friction lighter or a pilot flame.

(2) The neutral flame is obtained most easily by adjustment from an excess acetylene lame, which is recognized by the feather extension of the inner cone.

(3) A practical method of determining the amount of excess acetylene in a reducing flame is to compare the length of the feather with the length of the inner cone,
measuring both from the torch tip.

(4) The oxidizing flame adjustment is sometimes given as the amount by which the length of a neutral inner cone should be reduced, for example, one tenth.



Flame Temperature
Figure 551-88L-2068_15

h. Lighting the torch.

(1) To start the welding torch, hold it so as to direct the flame away from the operator, gas cylinders, hose, or any flammable material.

(2) Open the acetylene torch valve ¼-turn and ignite the gas by striking the sparklighter in front of the tip.

(3) Slowly open the oxygen valve.

(4) The flame changes to a bluish-white and forms a bright inner cone surrounded by an outer flame.

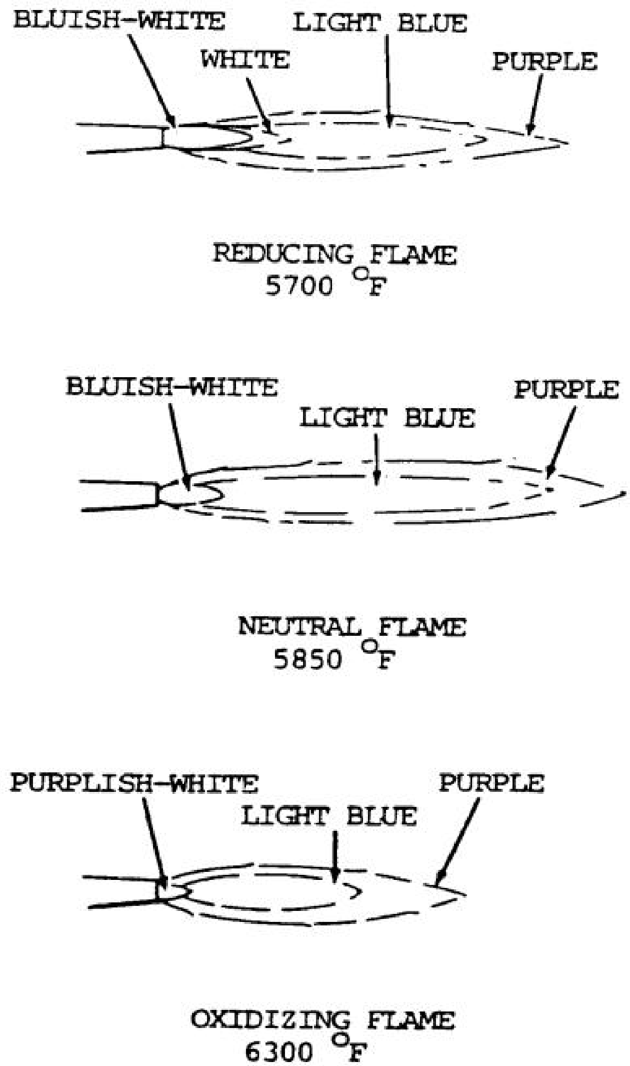
(5) The inner cone develops the high temperature required for welding.

i. Types of flames.

(1) Neutral

(2) Excess acetylene

(3) Excess oxygen (oxidizing)



Oxyacetylene Flames
Figure 551-88L-2068_16

j. Oxyfuel welding rods.

(1) The welding rod, which is melted into the welded joint, plays an important part in the quality of the finished weld.

(2) Good welding rods are designed to permit free flowing metal which will unite readily with the base metal to produce sound, clean welds of the correct composition.

(3) Welding rods are made for various types of carbon steel, aluminum, bronze, stainless steel, and other metals for hard surfacing.

k. Oxyfuel welding fluxes.

(1) Oxides of all ordinary commercial metals and alloys (except steel) have higher melting points than the metals themselves.

(2) The chemical characteristics and melting points of the oxides of different metals vary greatly.

(3) There is no one flux that is satisfactory for all metals, and there is no national standard for gas welding fluxes.

(4) Fluxes are usually in powder form.

(5) Other types of fluxes are of a paste consistency which is usually painted on the filler rod or on the work to be welded.

(6) Welding rods with a covering of flux are also available.

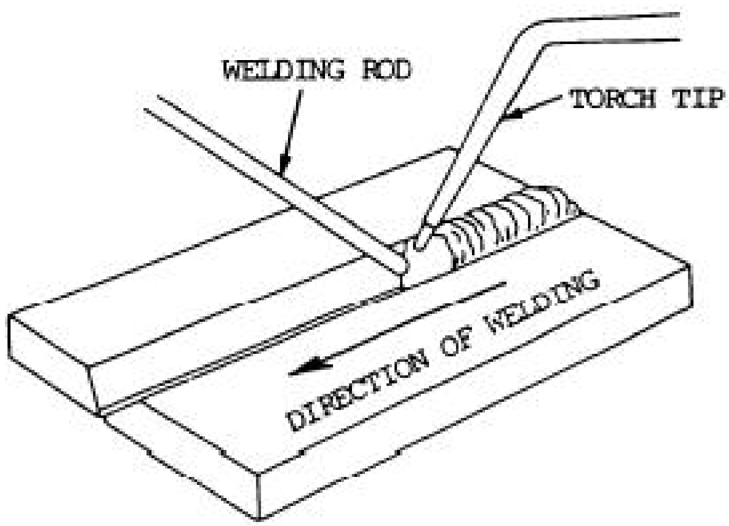
4. Perform basic metal welding procedures.

a. Forehand welding.

(1) The welding rod precedes the torch.

(2) The torch is held at approximately a 45 degree angle from the vertical in the direction of welding.

(3) The flame is pointed in the direction of welding and directed between the rod and the molten puddle.



Forehand Welding
Figure 551-88L-2068_17

(4) By moving the torch and the rod in opposite semicircular paths, the heat can be carefully balanced to melt the end of the rod and the side walls of the plate into a uniformly distributed molten puddle.

(5) The rod is dipped into the leading edge of the puddle so that enough filler metal is melted to produce an even weld joint.

(6) The heat which is reflected backwards from the rod keeps the metal molten.

(7) The metal is distributed evenly to both edges being welded by the motion of the tip.

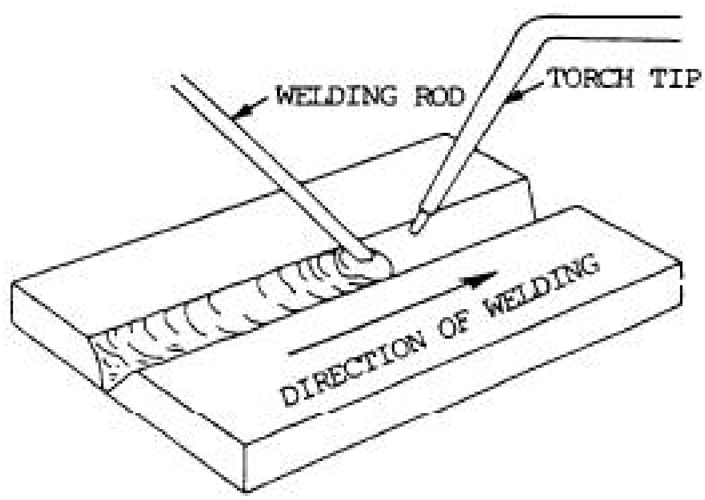
b. Backhand welding.

(1) The torch precedes the welding rod.

(2) The torch is held at approximately a 45 degree angle from the vertical away from the direction of welding, with the flame directed at the molten puddle.

(3) The welding rod is between the flame and the molten puddle.

(4) The position requires less transverse motion than is used in forehand welding.



Forehand Welding
Figure 551-88L-2068_18

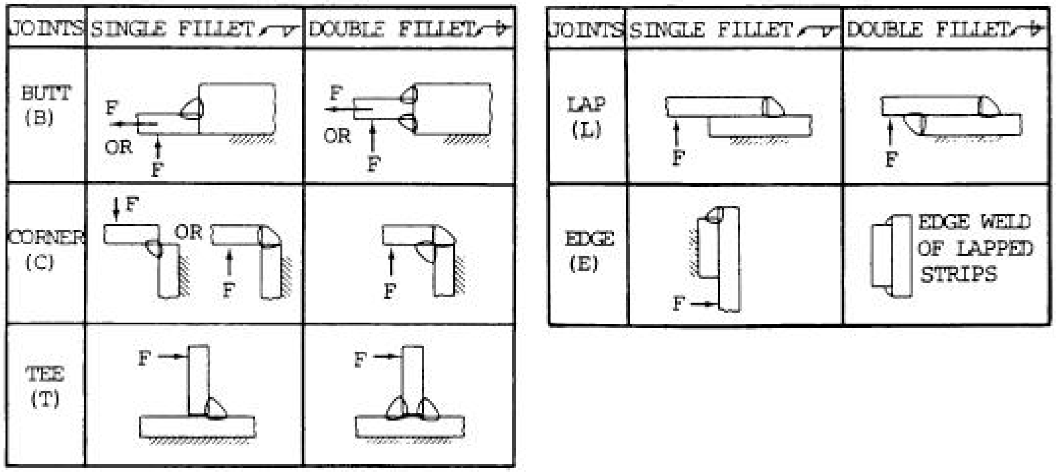
(5) Backhand welding may be used with a slightly reducing flame (slight acetylene feather) when desirable to melt a minimum amount of steel in making a joint.

(6) The increased carbon content obtained from this flame lowers the melting point of a thin layer of steel and increases welding speed.

c. Fillet welding.

(1) The fillet weld is the most popular of all types of welds because there is normally no preparation required.

(2) In some cases, the fillet weld is the least expensive, even though it might require more filler metal than a groove weld since the preparation cost would be less.



Fillet Used to Make the Five Basic Joint
Figure 551-88L-2068_19

(3) The fillet weld is expected to have equal length legs and thus the face of the fillet is on a 45 degree angle.

(4) In making the weld, a modified form of backhand technique should be used.

(5) The welding rod should be kept in the puddle between the completed portion of the weld and the flame.

(6) The flame should be pointed ahead slightly in the direction in which the weld is being made and directed at the lower plate.

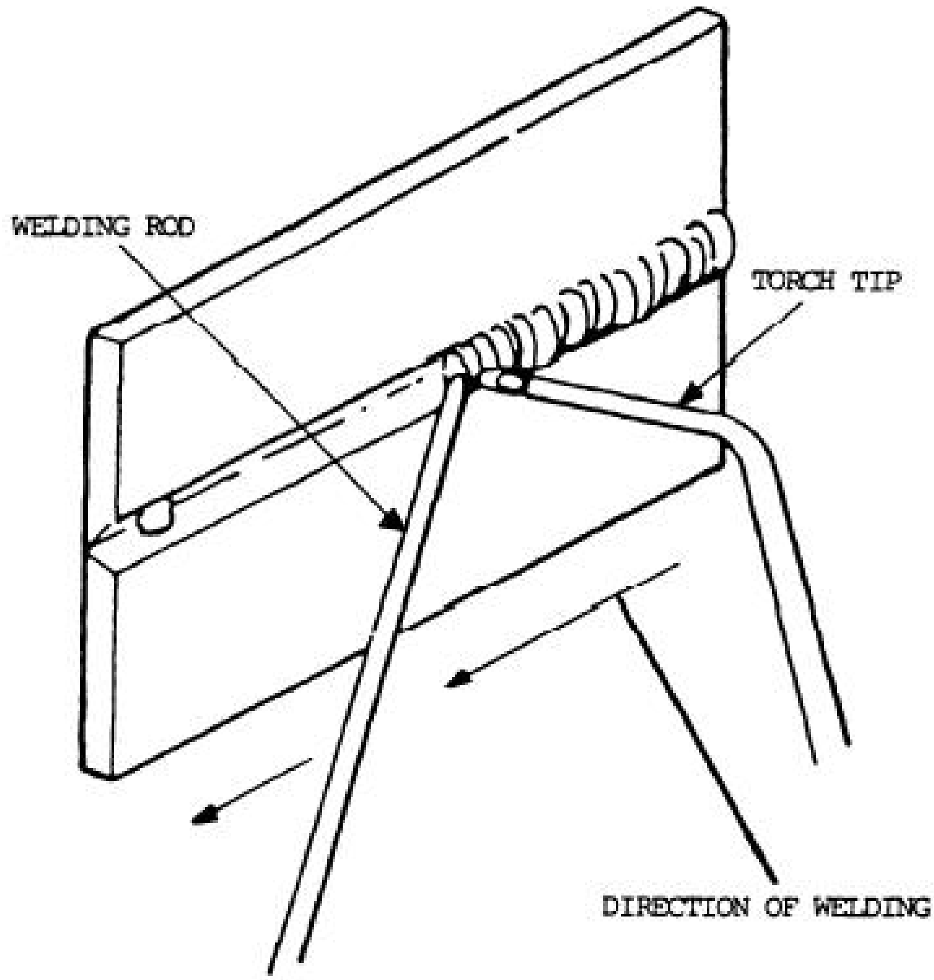
(7) To start welding, the flame should be concentrated on the lower plate until the metal is quite red.

(8) Then the flame should be directed so as to bring both plates to the welding temperature at the same time.

d. Horizontal position welding.

(1) The weld axis is approximately horizontal, but the weld type dictates the complete definition.

(2) Butt welding in the horizontal position is a little more difficult to master than flat position.



Horizontal Position

Figure 551-88L-2068_20

(3) Align the plates and tack weld at both ends.

(4) The torch should move with a slight oscillation up and down to distribute the heat equally to both sides of the joint, thereby holding the molten metal in a plastic state.

e. Flat position welding.

(1) This type of welding is performed from the upper side of the joint.

(2) The face of the weld is approximately horizontal.

(3) In order to make satisfactory bead welds on a plate surface, the flare motion, tip angle, and position of the welding flame above the molten puddle should be carefully maintained.

(4) Narrow bead welds are made by raising and lowering the welding flare with a slight circular motion while progressing forward.

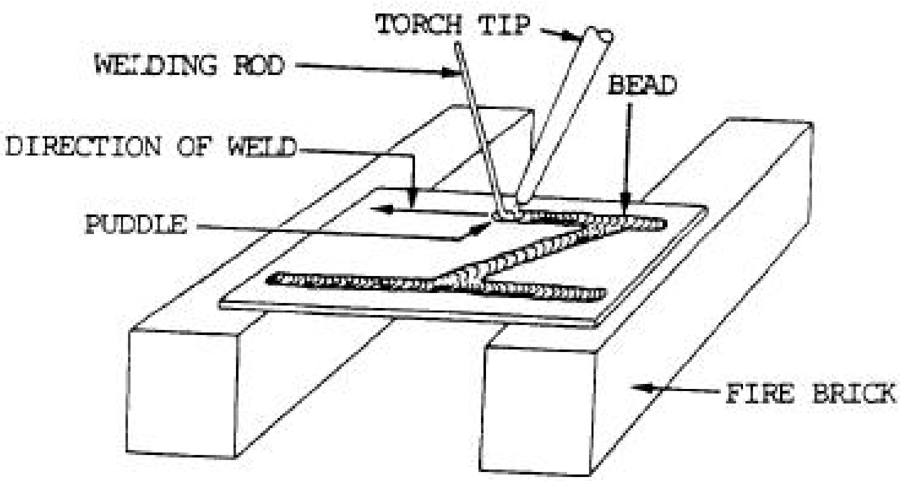
(5) The tip should form an angle of approximately 45 degrees with the plate surface.

(6) The flame will be pointed in the welding direction.

(7) A small puddle should be formed on the surface when making a bead weld with a welding rod.

(8) The welding rod is inserted into the puddle and the base plate and rod are melted together.

(9) The torch should be moved slightly from side to side to obtain good fusion.



Flat Position Weld
Figure 551-88L-2068_21

f. Butt welds.

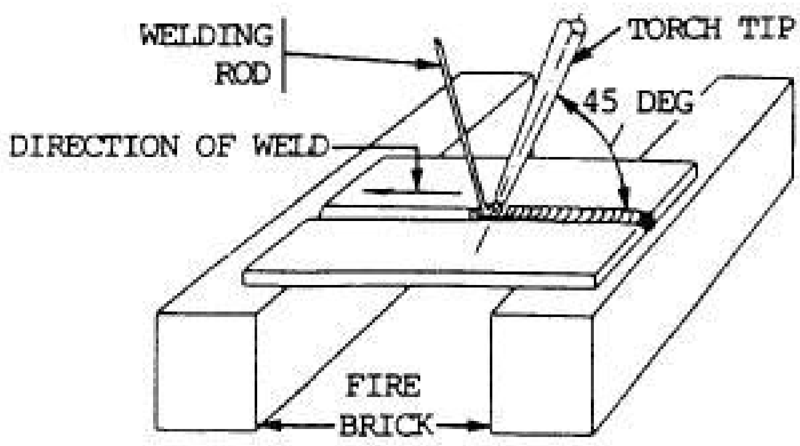
(1) Several types of joints are used to make butt welds in the flat position.

(2) The motion of the flame should be controlled so as to melt the side walls of the plates and enough of the welding rod to produce a puddle of the desired size.

(3) The motion of the flame should be controlled so as to melt the side walls of the plates and enough of the welding rod to produce a puddle of the desired size.

(4) By oscillating the torch tip, a molten puddle of a given size can be carried along the joint.

(5) Care should burning the metal, be taken not to overheat the molten puddle.



Butt Weld
Figure 551-88L-2068_22

g. Vertical position welding.

(1) In vertical position welding, the axis of the weld is approximately vertical.

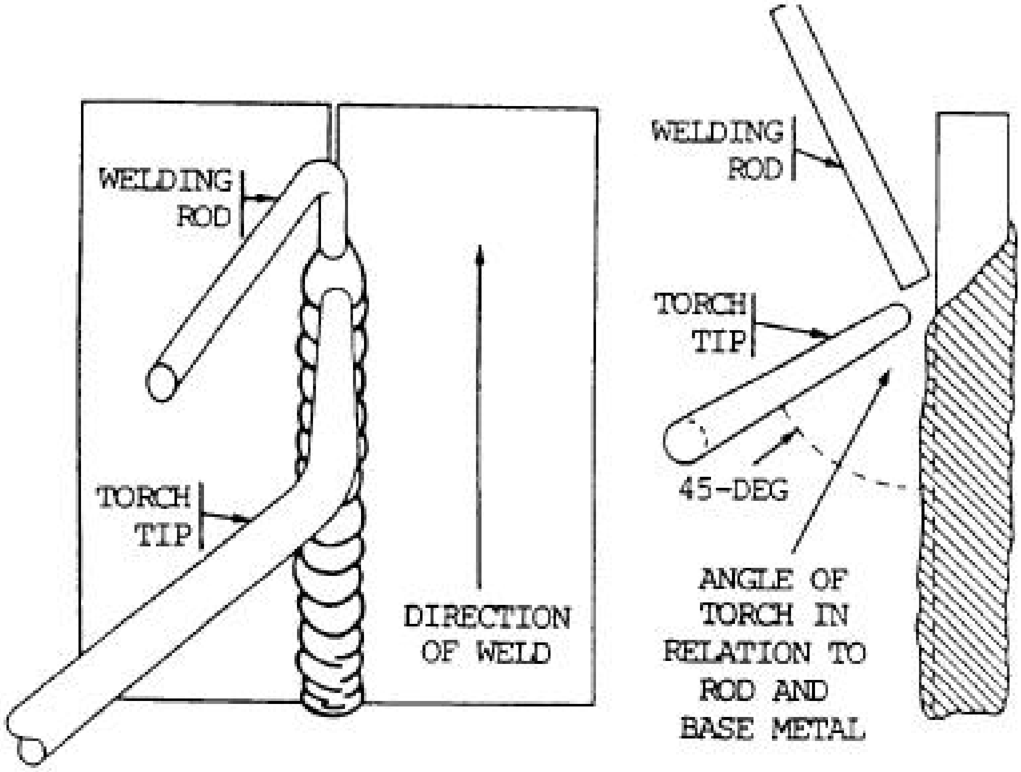
(2) When welding is done on a vertical surface, the molten metal has a tendency to run downward and pile up.

(3) The flow of metal can be controlled by pointing the flame upward at a 45 degree angle to the plate, and holding the rod between the flame and the molten puddle.

(4) The manipulation of the torch and the filler rod keeps the metal from sagging or falling and ensures good penetration and fusion at the joint.

(5) Both the torch and the welding rod should be oscillated to deposit a uniform bead.

(6) The welding rod should be held slightly above the center line of the joint, and the welding flame should sweep the molten metal across the joint to distribute it evenly.



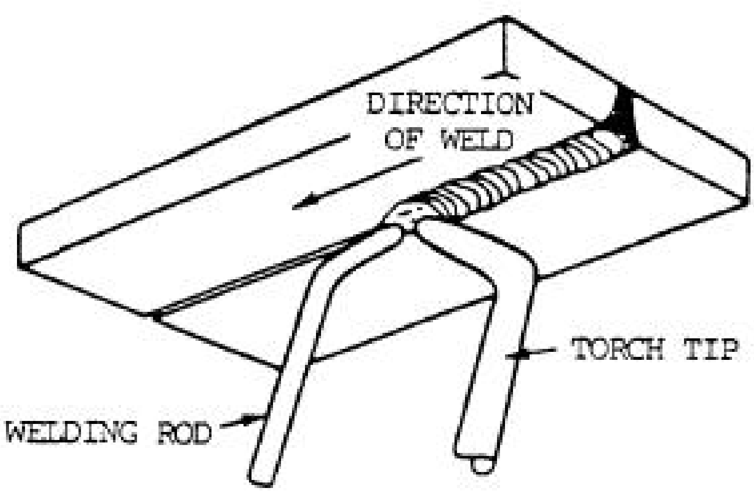
Vertical Position Welding.
Figure 551-88L-2068_23

h. Overhead position welding.

(1) Bead welds in overhead welding, the metal deposited tends to drop or sag on the plate, causing the bead to have a high crown.

(a) To overcome this difficulty, the molten puddle should be kept small, and enough filler metal should be added to obtain good fusion with some reinforcement at the bead.

(b) If the puddle becomes too large, the flame should be removed for an instant to permit the weld metal to freeze.



Overhead Position

Figure 551-88L-2068_24

(2) Butt joints the flame should be directed so as to melt both edges of the joint.

(a) Sufficient filler metal should be added to maintain an adequate puddle with enough reinforcement.

(b) The welding flame should support the molten metal and distribute it along the joint.

(c) Only a small puddle is required, so a small welding rod should be used.

(d) Care should be taken to control the heat to avoid burning through the plates.

5. Perform basic metal cutting procedures.

a. Reaction of oxygen and iron is used in the oxyacetylene cutting process.

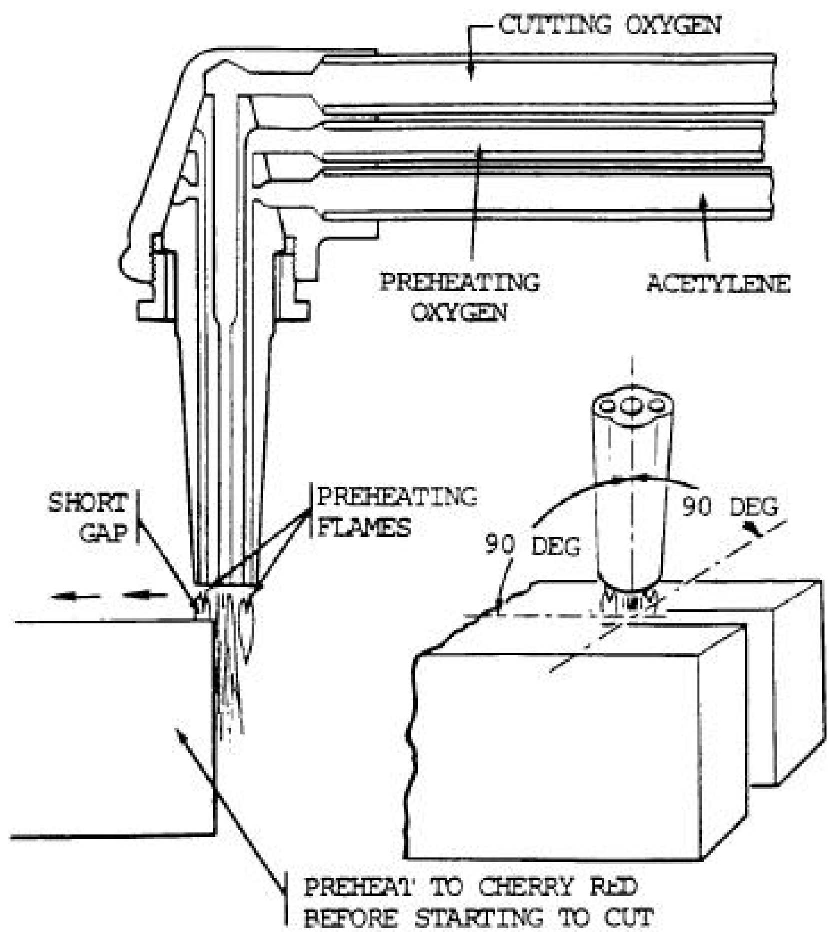
(1) A stream of oxygen is firmly fixed onto the metal surface after it has been heated to the kindling temperature.

(2) The hot metal reacts with oxygen, generating more heat and melting.

(3) The molten metal and oxide are swept away by the rapidly moving stream of oxygen.

(4) The oxidation reaction continues and furnishes heat for melting another layer of metal.

(5) The cut progresses in this manner.



Cutting Process
Figure 551-88L-2068_25

b. Cutting steel and cast iron.

(1) High carbon steels.

(a) The action of the cutting torch on these metals is similar to a flame hardening procedure, in that the metal adjacent to the cutting area is hardened by being heated above its critical temperature by the torch and quenched by the adjacent mass of cold metal.

(b) This condition can be minimized or overcome by preheating the part from 500 to 600°F (260 to 316°C) before the cut is made.

(2) Waster plate on alloy steel.

(a) The cutting action on an alloy steel that is difficult to cut can be improved by clamping a mild steel “waster plate” tightly to the upper surface and cutting through both thicknesses.

(b) This waster plate method will cause a noticeable improvement in the cutting action, because the molten steel dilutes or reduces the alloying content of the base metal.

(3) Chromium and stainless steels.

(a) These and other alloy steels that previously could only be cut by a melting action can now be cut by rapid oxidation through the introduction of iron powder or a special nonmetallic powdered flux into the cutting oxygen stream.

(b) This iron powder oxidizes quickly and liberates a large quantity of heat.

(c) This high heat melts the refractory oxides which normally protect the alloy steel from the action of oxygen.

(d) These molten oxides are flushed from the cutting face by the oxygen blast.

(e) Cutting oxygen is enabled to continue its reaction with the iron powder and cut its way through the steel plates.

(f) The nonmetallic flux, introduced into the cutting oxygen stream, combines chemically with the refractory oxides and produces a slag of a lower melting point, which is washed or eroded out of the cut, exposing the steel to the action of the cutting oxygen.

(4) Cast iron.

(a) Cast iron melts at a temperature lower than its oxides.

(b) In the cutting operation, the iron tends to melt rather than oxidize.

(c) The oxygen jet is used to wash out and erode the molten metal when heated to a high temperature.

(d) To make this action effective, the cast iron must be preheated to a high temperature.

(e) Much heat must be liberated deep in the cut.

(f) This is done by adjusting the preheating flames so that there is an excess of acetylene.

(Asterisks indicates a leader performance step.)

Evaluation Guidance: None

Evaluation Preparation: None

PERFORMANCE MEASURES	GO	NO-GO	N/A
1. Identified welding metals, protective clothing and equipment for electric arc welding.			
a. Metals			
b. Personal protective clothing and equipment.			
c. Ventilation in confined spaces.			
d. Electric arc welding equipment and accessories.			
2. Explained electric arc theory and welding procedures.			
3. Demonstrated basic knowledge of metal welding and cutting.			
a. Gases.			
b. Base metal preparation.			
c. Multiple layer welding.			
d. Weld quality.			
e. Working pressures for welding operations.			
f. Flame adjustment and flame types.			
g. Flare adjustment.			
h. Lighting the torch.			
i. Types of flames.			
j. Oxyfuel welding rods.			
k. Oxyfuel welding fluxes.			
4. Performed basic metal welding procedures.			
a. Forehand welding.			
b. Backhand welding.			
c. Fillet welding.			
d. Horizontal position welding.			
e. Flat position welding.			
f. Butt welds.			
g. Vertical position welding.			
h. Overhead position welding.			
5. Performed basic metal cutting procedures.			
a. Reaction of oxygen and iron.			
b. Cutting steel and cast iron.			
(1) High carbon steels.			
(2) Waster plate on alloy steel.			
(3) Chromium and stainless steels.			
(4) Cast iron.			

Supporting Reference(s):

Step Number	Reference ID	Reference Name	Required	Primary
	TC 9-237	OPERATORS CIRCULAR WELDING THEORY AND APPLICATION	No	No

Environment: Environmental protection is not just the law but the right thing to do. It is a continual process and starts with deliberate planning. Always be alert to ways to protect our environment during training and missions. In doing so, you will contribute to the sustainment of our training resources while protecting people and the environment from harmful effects. Refer to FM 3-34.5 Environmental Considerations and GTA 05-08-002 ENVIRONMENTAL-RELATED RISK ASSESSMENT.

Safety: In a training environment, leaders must perform a risk assessment in accordance with ATP 5-19, Risk Management. Leaders will complete the current Deliberate Risk Assessment Worksheet in accordance with the TRADOC Safety Officer during the planning and completion of each task and sub-task by assessing mission, enemy, terrain and weather, troops and support available-time available and civil considerations, (METT-TC). Note: During MOPP training, leaders must ensure personnel are monitored for potential heat injury. Local policies and procedures must be followed during times of increased heat category in order to avoid heat related injury. Consider the MOPP work/rest cycles and water replacement guidelines IAW FM 3-11.4, Multiservice Tactics, Techniques, and Procedures for Nuclear, Biological, and Chemical (NBC) Protection, FM 3-11.5, Multiservice Tactics, Techniques, and Procedures for Chemical, Biological, Radiological, and Nuclear Decontamination.

Prerequisite Individual Tasks : None

Supporting Individual Tasks : None

Supported Individual Tasks : None

Supported Collective Tasks : None

ICTL Data :

ICTL Title	Personnel Type	MOS Data
88L20 Watercraft Engineer	Enlisted	MOS: 88L, Skill Level: SL2, Duty Pos: TFS, LIC: EN
88L30 Watercraft Engineer	Enlisted	MOS: 88L, Skill Level: SL3, Duty Pos: TFR, LIC: EN
88L40 Watercraft Engineer	Enlisted	MOS: 88L, Skill Level: SL4, Duty Pos: TGB, LIC: EN, SQI: O